DOCUMENT RESUME

ED 248 986 PS 014 613

AUTHOR Gross, Thomas F.
TITLE State Anxiety, Memory and Children's Problem Solving (with Supplement Report).
PUB DATE Apr 84
NOTE 37p.; Paper presented at the Annual Meeting of the Western Psychological Association (Los Angeles, CA, April 5-7, 1984).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Anxiety; Elementary Education; *Elementary School Students; *Feedback; *Hypothesis Testing; *Memory; Performance Factors; *Problem Solving; Visual Stimuli
IDENTIFIERS Rule Application; *State Anxiety

ABSTRACT

Two experiments investigated relationships between state anxiety, memory processes, and children's performance on problem-solving tasks. Participants were second and sixth graders in a private elementary school in Redlands, California. In both experiments, subjects responded to three training and eight test problems presented in the introtact format. In this format, sets of cards are shown to children, one card at a time. On each card is a pair of orthogonal figures consisting of unique combinations of four dimensions (size, shape, pattern, color); dimensions have two values each. According to this method, children were shown a card and asked to point to the figure they believed contained the experimenter-defined answer for that set of cards. In both experiments, a memory aid was made available on half the test problems. Aids consisted of visual exemplars of each dimensional value and the name of that value, which was printed in block letters on the face of the card. The experiments differed only in the manner in which feedback and introtacts were delivered. In the first experiment, the stimulus card remained visible during feedback and was changed immediately after the child verbalized a hypothesis about the solution. In the second experiment, children received feedback and were required to formulate hypotheses in the absence of the stimulus cards. Subsequently, subjects were categorized into low, moderate, and high state-anxious groups on the basis of responses to questions about how they felt while solving the problems. Analysis of problem-solving behavior focused on the number of problems solved, logical rule use, and strategy use. Results indicated that memory assistance brought about more rapid solutions for both age groups; relatively little performance deficit resulted from high state-anxiety. (RH)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

X This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

ED248986

State Anxiety, Memory and Children's Problem Solving*

Thomas F. Gross
University of Redlands
Redlands, CA 92373

PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Thomas F. Gross

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

PS 014613

*A more detailed description of the two studies reported in this paper is available on request.

"The general impression one receives is that the relationship between the manifest anxiety scale and learning is, like extra-sensory perception (ESP), a delicate flower that blooms only in certain environments." (Bending & Vaughan, 1957).

Much of our expectations about the relationship between anxiety and performance stems from early research conducted during the 1950's and 1960's using Taylor's (1953) Manifest Anxiety Scale. Taylor developed her scale as a way to measure drive, an important component of Hull and Spence's equation for predicting performance (R=(f)HxD). Taylor (1956) and Spence and others (Spence, Farber, & McFann, 1956: Spence, Taylor, & Ketchel, 1956) believed that under high drive the individual would be aided in performance if a dominant habit was relevant to successful task completion. If, on the other hand, a less dominant habit was critical to performance, high drive would make new learning difficult as the dominant habit would continue to be expressed under high drive levels. Taylor's scale (a paper and pencil inventory derived from the MMPI) provided a convenient operational definition of the construct "drive."

Early research seemed to demonstrate that anxiety influenced performance in the manner predicted by Hull-Spence theory on a variety of learning tasks (e.g., Baron & Connor, 1960; Bitterman & Holtzman, 1952; Spence & Beecroft, 1954). These successes were not only taken as support for

Hull-Spence theory, but also as support for what appeared to be an efficient and economical way to assess drive (anxiety).

Despite what appeared to be the initial success of both the Manifest Anxiety Scale and Hull-Spence theory, a critical review of this early literature reveals that the relationship between anxiety and performance was not as straight forward as we might wish to believe. Studies often reported contradictory, inconsistent, or null results (e.g., Bendig & Vaughan, 1957; Bindra, Patterson, & Strzelecki, 1955; Buss & Gerjouv, 1958; Prokasky & Truax, 1959).

With the changing interests of psychologists during the 1970's, anxiety research also took on a different look. We find anxiety redefined as either a state or trait. State anxiety anxiety was defined as some "subjective, consciously perceived feeling of tension and apprehension, and heightened automatic nervous system activity" (Spielberger, Gorsuch, & Luschene, 1970). State anxiety was believed to fluctuate over time whereas trait anxiety was some relatively stable characteristic of anxiety proneness. The reconsideration of anxiety in terms of cognitive components brought about research directed at discovering the relationship between this affective dimension of mental life and other cognitive processes involved in concept discovery and problem solving.

The influence of state anxiety on performance, it was believed, could be realized at one of two levels. First, anxiety might affect performance by interfering with the use

of various logical rules that are essential to problem solving (e.g., White, 1970). Second, anxiety might affect the use of a variety of subprocesses (e.g., perception and memory) that support problem solving.

A variety of research with older children and adults tends to support the latter interpretation. That is, under less memory demanding conditions, high state-anxious individuals may perform as well as low and moderately state-anxious subjects on conceptual tasks. Furthermore, providing high state-anxious subjects with memory assistance on problem solving tasks improves their performance relative to nonmemory assisted trials (Leherissey, O'Neil, & Hanson, 1971; Sieber, Kameya, & Paulson, 1970).

In one study with adults, an attempt was made to localize the effect of anxiety within the complex process that constitutes problem solving. Gross and Mastenbrook (1980) had college students solve concept-discovery problems with and without the use of a memory aid. Compared to their performance without memory assistance, memory assisted, high anxious subjects solved more problems and used more efficient strategies. It was concluded that the use of more efficient strategies necessitated the better management of memory. Under high anxiety, subjects were less likely to use memory efficiently and consequently were prone to use less efficient solution strategies which led to fewer problem solutions.

Little research has been conducted to date examining the relationship between state anxiety, memory processes, and

children's performance on problem-solving tasks. Such an oversight is curious considering the reported anxiety experienced by children in evaluative classroom situations. This research was initiated with the hope of partially filling this void.

Method

The introtact probe procedure was used and on other problems in children (second and sixth graders). In this procedure cards are shown individually to children. These cards contain two orthogonal figures varying in four, bivalued dimensions. The child is shown a set of these cards (constituting a problem) and from feedback provided by the experimenter, he or she is expected to discover some answer (one of eight values) the experimenter has in mind. As each card is shown, the child is asked to point to the figure on the card that is believed to contain the answer. After the experimenter has provided feedback, children are asked to state verbally (an introtact probe) what they believe to be the answer to the problem. On some of the problems children are allowed to use a visual memory aid to remember possible solution alternatives on others they are not. In all, eight problems were presented; four with and four without memory aids.

Two experiments were conducted and varied in the manner in which feedback was presented. In the first experiment the stimulus card remained visible during feedback and was changed

immediately after the child verbalized an hypothesis about the solution. In the second experiment, as soon as the child chose one of the two figures, the card was removed exposing a blank card. Children received feedback and were required to formulate solution hypotheses in the absence of any visual information (thus increasing the memory requirements of the task beyond those in Experiment 1).

Following problem solving, children were asked to respond to questions about how they felt while solving problems. The questions came from the State-Trait Anxiety Inventory for Children (Spielberger, Edwards, Luschene, Montuori, & Platzek, 1973). On the basis of these scores, children were placed into low, moderate, and high state-anxious groups for the purpose of data analysis.

Results

Several measures of performance were considered. These measures fall under three general classes: measures of (a) solution performance, (b) logical rule use, and (c) strategy use. Solution performance measures were the number of problems solved (to be credited with a problem solution, the correct answer had to be verbalized on at least two consecutive probe trials prior to the end of the problem) and speed of solution.

A number of logical rules were also evaluated. One logical rule involves knowledge that hypotheses must be consistent with immediately preceding positive and negative

feedback (H con F+ and H con F-). Other logical rules involve knowledge that one maintains confirmed hypotheses (win-stay) and discards disconfirmed hypotheses (lose-shift). A final logical rule (local consistancy) involves knowledge that one selects as a new hypothesis, one from the opposite set of values to that instance that was just chosen and found to be incorrect.

In addition to logical rule use, solution strategies were also examined. Strategies are systematic plans for testing hypotheses. The most efficient of these strategies is focusing. Using this strategy one can solve problems in exactly three trials (cards). Although this strategy is the most efficient, it is also the most memory demanding. One other hypothesis pattern was considered and this was the frequency of random hypothesis sequences. These are hypothesis patterns that are inconsistently related to the pattern of feedback subjects receive. As such these patterns represent disorganized attempts to use hypotheses in a solution-achieving manner.

Experiment 1

Solution performance. Second graders were aided in both the frequency with which they solved problems and the speed with which problems were solved when memory assistance was provided. Sixth graders tended to solve problems more rapidly when memory assisted (Table 1).

Logical rule use. Second graders tested more hypotheses that were consistent with negative feedback when they were

memory assisted. Furthermore, this facilitation was greatest for high state-anxious children (Table 2).

Strategy use. Sixth graders used more focusing when memory assisted. It was also found that high state anxious, sixth graders used more random hypothesis sequences (Table 3).

Experiment 2

Due to the lack of any pronounced effects for state anxiety or any significant interaction between memory and state anxiety in the first experiment, a second study was conducted. In this study, the memory demands of the problem solving task was increased by delaying and presenting feedback without visual stimulus support.

Solution performance. Both second and sixth graders solved more problems and solved them more rapidly when they received memory assistance (Table 4).

Logical rule use. Low anxious sixth graders tested more hypotheses that were consistent with negative feedback when provided with memory assistance. And, low state anxious, sixth graders were less locally consistent than moderately anxious children (Table 5).

Strategy use. Second graders used more focusing and used significantly fewer random hypothesis sequences when provided with memory assistance (Table 6).

Discussion

There are two striking impressions to be found in these results. The first is the degree to which providing young children with memory assistance facilitates problem solving.

In both experiments memory assistance brought about more rapid solutions for both age groups. In Experiment 1, for younger children, and in Experiment 2 for both age groups, memory assistance prompted a greater number of solutions. These data also suggest that the provision of memory assistance facilitates the occurrence of more efficient solution strategies. Why, in Experiment 1, older but not younger children and, in Experiment 2, younger but not older children, used more focusing and fewer random hypothesis sequences is unclear.

The other striking feature of these results is the relative absence of any performance deficit as a consequence of high state anxiety. The failure to find an effect doesn't, of course, suggest that state anxiety does not interfere with performance in some cases. Intuition and experience suggest that it does. However, empirical demonstrations of this effect, as so eloquently noted by Bendig and Vaughan (1957), may not be as reliable as intuition and common sense would lead us to believe.

Presuming for the moment that our intutions about the relationship between state anxiety and performance are correct, we might consider some methodological problems in conducting state anxiety research with children. These methodological problems may limit the scope of our inquiry. First, we might consider whether the self-report inventories used to assess state anxiety (or for that matter any subjective state) in young children are valid. Younger children, for example, are

less sophisticated at describing their subjective states and deciphering the meaning of various adjective descriptions of emotional states. Second, the manner in which anxiety groups are constituted may bias us against finding significant anxiety effects. It is common practice, for example, to constitute groups of state anxious children in the manner described in this paper. Unfortunately (for the purposes of research), I am compleled to question the meaningfulness of any "high" state anxious group so constituted. These groupings are arbitrary and, in fact, merely represent the high scorers in what is an otherwise well adjusted, normal functioning group of children. A more important test of the relationship between memory, state anxiety, and performance may await the assessment of clinically constituted high, state anxious groups of children.

References

Baron, M.R. & Connor, J.P. (1960). Eyelid conditioned responses with various level of anxiety. Journal of Experimental Psychology, 60, 310-313.

Bendig, A.W. & Vaughan, C.J. (1957). Manifest anxiety, disrimination, and transposition. American Journal of Psychology, 70, 286-288.

Bindra, D., Patterson, A.L. & Strzelecki, J. (1958). On the relationship between anxiety and conditioning. Canadian Journal of Psychology, 57, 249-250.

Bitterman, M.E. & Holtzman, W.H. (1952). Conditioning and extinction of the galvanic skin response as a function of anxiety. Journal of Abnormal and Social Psychology, 47, 615-523.

Buss, A.H. & Gerjuoy, I.R. (1958). Verbal conditioning and anxiety. Journal of Abnormal and Social Psychology, 57, 249-250.

Gross, T.F. & Mastenbrook, M. (1980). Examination of the effects of state anxiety on problem solving efficiency under high and low memory conditions. Journal of Educational Psychology, 72, 605-609.

Leherissey, B.L., O'Neil, H.F. & Hansen, D.N. (1971). Effects of memory support on state anxiety and performance in computer-assisted learning. Journal of Educational Psychology, 62, 413-420.

Prokasky, W.F & Truax, C.B. (1959). Reflex and conditioned responses as a function of manifest anxiety. American Journal of Psychology, 72, 262-264.

Sieber, J.E., Kameya, L.I. & Paulson, F.L. (1970). Effect of memory support on the problem solving ability of test-anxious children. Journal of Educational Psychology, 61, 159-168.

Speilberger, C.D., Gorsuch, R.L. & Luschene, R.E. (1970). The State-Trait Anxiety Inventory. Palo Alto, CA: Consulting Psychologists Press.

Speilberger, C.D., Edwards, Montuori, & Platzek, D. (1973). The State-Trait Anxiety Inventory for Children. Palo Alto, CA: Consulting Psychologists Press.

Spence, K.W. & Beecroft, R.S. (1954). Differential conditioning and level of anxiety. Journal of Experimental Psychology, 48, 399-403.

Spence, K.W., Farber, I.E. & McFann, H.H. (1956). The relation of anxiety (drive) level to performance in competitional and non-competitional paired associates learning. Journal of Experimental Psychology, 52, 296-305.

Spence, K. W., Taylor, J.A. & Ketchel, R. (1956). Anxiety (drive) level and degree of competition in paired associate learning. Journal of Experimental Psychology, 52, 306-310.

Taylor, J.A. (1956). Drive theory and manifest anxiety. Psychological Bulletin, 53, 303-320.

Taylor, J.A. (1953). A personality scale of manifest anxiety. Journal of Abnormal and Social Psychology, 48, 285-290.

Table 1. Experiment 1: Mean number of problems solve
a function of anxiety and memory condition.

		Low		M
		Mem. Asst	Nonasst.	
Second Grade	Number of Prbs Solved	3.17	2.67	
	Trials to Last Error	4.88	3.62	
Sixth Grade	Number of Prbs Solved	3.33	3.33	
	Trials to Last Error	5.51	4.54	

d and number of trials to last error as

Anxiety Level			
Moderate		High	
em Asst.	Nonasst.	Mem Asst	Nonasst.
3.1	2.17	2.5	2.25
4.63	2.87	3.81	3.2
3.53	3.47	3.56	3.19
5.99	5.65	5.87	4.95

Table 2. Experiment 1: Mean percentage of instanc
appropriately as a function of anxiety an

		Low Mem. Asst	Nonasst.
Second Grade	H con F-	1.0	1.0
	Local Con.	1.0	1.0
Sixth Grade	H con F-	.96	1.0
	Local Con.	.97	.97

es when problem-solving rules were used
d memory condition.

Anxiety Level			
Moderate		High	
Mem Asst.	Nonasst	Mem Asst.	Nonasst.
.96	.95	.99	.93
.97	.92	.98	.98
.99	.98	.97	1.0
.99	1.0	.94	.96

Table 3. Experiment 1: Mean percentage of problem
sequences were found as a function of anx

		Low	
		Mem. Asst	Nonasst.
Second Grade	Focusing	.44	.33
	Rand. Hyp. Sequences	.48	.39
Sixth Grade	Focusing	.67	.31
	Rand. Hyp. Sequences	.18	.27

s on which focusing and random hypothesis
iety and memory condition.

Anxiety Level			
Moderate		High	
Mem Asst.	Nonasst	Mem. Asst	Nonasst.
.18	.31	.35	.24
.40	.44	.46	.54
.66	.54	.46	.33
.11	.16	.34	.40

Table 4. Experiment 2: Mean number of problems sol
a function of anxiety and memory conditio

		Low	
		Mem. Asst	Nonasst
Second Grade	Number of Prbs Solved	3.17	1.83
	Trials to Last Error	4.78	2.34
Sixth Grade	Number of Prbs Solved	3.67	3.0
	Trials to Last Error	5.75	4.29

ved and number of trials to last error as
n

Anxiety Level			
Moderate		High	
Mem Asst.	Nonasst	Mem Asst.	Nonasst.
3.25	1.91	2.2	2
4.77	2.25	3.58	1.1
3.92	3.17	3.56	3.0
6.3	5.08	5.31	4.08

Table 5. Experiment 2: Mean percentage of inst
appropriately as a function of anxiety

		Low	
		Mem. Asst.	Nonasst.
Second Grade	H con F-	.77	.77
	Local Con.	.76	.74
Sixth Grade	H con F-	.78	.63
	Local Con.	.63	.66

ances when problem-solving rules were used
and memory condition.

Anxiety Level			
Moderate		High	
Mem. Asst.	Nonasst.	Mem. Asst	Nonasst.
.81	.72	.74	.81
.78	.73	.72	.78
.83	.86	.84	.79
.83	.83	.81	.71

Table 6. Experiment 2: Mean percentage of probl
sequences were observed as a function o

		Low	
		Mem. Asst.	Nonasst.
Second Grade	Focusing	.30	.14
	Rand. Hyp. Sequences	.49	.61
Sixth Grade	Focusing	.39	.46
	Rand. Hyp. Sequences	.46	.43

ems on which focusing and random hypothesis
of anxiety and memory condition

Anxiety Level			
Moderate		High	
Mem. Asst.	Nonasst.	Mem. Asst.	Nonasst.
.45	.21	.22	.05
.80	.67	.65	.80
.55	.46	.38	.32
.32	.32	.42	.47

The following is a supplement to the methods and results sections of the paper entitled, "The Effect of State Anxiety on Children's Problem Solving," presented to the 1984 meeting of the Western Psychological Association.

EXPERIMENT 1

METHOD

Design and Procedure

Problems were presented in the introtact format. In this format, sets of cards are shown to children, one card at a time. On each card is a pair of orthogonal figures. Most often (and as was true of this research) these figures consist of the unique combinations of four dimensions with two values each. Children are shown a card and are asked to point to the figure that they believe contains the experimenter-defined answer (one of eight values) for that set of cards. After receiving feedback, children are asked to state what they believe to be the answer.

When solving these problems, subjects must test hypotheses using several logical rules. Hypotheses need to be consistent (H con) with the immediately preceding feedback, be it either positive (F+) or negative (F-). If subjects are testing an hypothesis and receive confirmation, they should retain it (the win-stay rule) and if they receive negative feedback, they should change it (the lose-shift rule) to one that is consistent with the alternate set of values (the local consistency rule).

In addition to using logical rules, hypothesis testing must be strategic (i.e., subjects should use some systematic plan for testing hypotheses) if solutions are to be reliable. The most efficient strategy for solving problems is focusing. Subjects who use a focusing strategy not only use the logical rules defined above, they also use information in a parsimonious fashion. Subjects

who focus must remember what all possible solutions to a problem are after receiving feedback on the first trial. Thereafter, they must eliminate from this hypothesis set those values that have been disconfirmed.

Children were tested individually after random assignment to one of the conditions created by the combination of two problem presentation orders and the availability of memory aids to some children on even numbered, while for others on odd numbered, problems. (Post hoc analyses revealed that neither the order in which problems were presented nor the availability of memory aids on even versus odd numbered problems affected task performance. Consequently, data were combined across problems and presentation orders for the purpose of data analyses.)

Children received, in all, three practice problems: four test problems with memory aids, and four test problems without memory aids. The presence or absence of memory aids was alternated from trial to trial for each subject. After solving problems, children were asked to respond to statements from the state scale (Form C-1) of the State Trait Anxiety Inventory for Children, describing how they felt while they were solving problems. Based upon their scores, children were placed into three state-anxiety groups. In both Experiment 1 and 2, children were assigned to the low state-anxious group if they obtained raw scores of 29 or lower and to the high state-anxious group if they obtained raw scores above 32. Children receiving middle scores were placed in the moderate state-anxious group.

Training. Prior to the test phase of the experiment, children were given three training problems. They were shown a deck of cards and told that each deck would be considered a problem. They were told that they would be asked to discover an answer, one of eight values (red, blue, large, small, circle, square, dotted, or striped), that the experimenter would be thinking about on each problem. Children were then told that when they were shown a card, they were always to point to

the figure on the card that they believed contained the answer. After each choice, and with the stimulus card in view, the experimenter told the child if his or her choice was correct. The child's task was to discover the value that was common to all of the figures that the experimenter designated correct. It was emphasized that only one value would define the solution to each problem and that on no occassion would the answer consist of a combination of values.

The first practice problem was a simple discrimination learning problem. Children were given feedback after each trial and trained to a criterion of seven consecutively correct responses. After each criterion was reached, children were asked to verbalize their answer. If they were unable to name the answer common to all of their last nine choices, the answer was provided and the children were shown that, indeed, that answer had been common to all of the figures that had been designated correct.

The second practice problem again consisted of a deck of 46 cards. On this problem, children were introduced to the introtact probe. Again children were asked to point to the figure that they believed contained the answer to the problem. Following feedback, and with the card in view, they were asked to verbalize what they believed was the answer to the problem. If a child said that he or she didn't know, the experimenter prompted a response by saying, "What is your best guess about what the answer might be?"

On this problem, children were trained to a criterion of four correct consecutive responses with three intervening verbalizations of the correct answer. That is, children were encouraged to continue to verbalize and point to the figure with the correct answer on consecutive trials. In this way they learned that a continuation of the procedure didn't necessarily mean that their answer was incorrect.

On the third training problem, children were introduced to the memory aid, and training continued with the introtact format. After the first card was shown and feedback given, children were provided a memory aid (a set of eight cards depicting each of the eight values in the stimulus set with the name of the value printed on the face of the card). Children were told that they could, if they wished, use the cards to help them solve the problem. They were reminded that the first positive examplar had the answer to the problem and that one of the four values in that figure had to be the answer. They were shown that four cards in the memory set could be used to remember possible solution. Children were told to find cards that would help them remember possible answers and to place them in front of themselves. If they didn't spontaneously choose all four relevant values, the experimenter prompted them to make additional choices. After a child had all of the relevant memory aids in front of him or her self, the experimenter asked the child to guess the answer. Following a response, the procedure was continued as in the previous problem to a criterion of four consecutive correct choices with an appropriate verbal report on the interveneing introtacts.

Test Phase. During the test phase of the experiment, children were asked to solve eight problems, half with and half without the memory aid available. Each problem consisted of ten cards arranged such that the answer to the problem could be deduced with the presentation of any three consecutive cards. On memory-assisted problems the eight memory-aid cards were provided to children who were told they could use them to help find the answer. No further prompting or encouragement was given to use the memory aid, although the aid was clearly visible and accessible at any time during problem solution. The presentation of cards was subject paced, i.e., a new card was presented only after the subject verbalized what he/she believed was the answer to the problem on each trial. Children were tested to a criterion of three correct choices and two consecutive verbalizations of the

correct answer. (Although testing was discontinued after criterion was reached, children who reached criterion prior to the tenth trial were, nonetheless, credited with correct choices on the remaining trials for the purposes of scoring.)

Subjects

Children participating in this study were second - ($\bar{X}$ age=90 mo., S.D.=9 mo.) and fifth- and sixth-graders ($\bar{X}$ age=122.5 mo., S.D.=13 mo.) attending a private elementary school in Redlands, California. In both Experiment 1 and 2, children were assigned to the low state-anxious group if they obtained raw scores on the STAIC of 29 or lower and to the high state-anxious group if they obtained raw scores of 32 or above. Children receiving middle scores were placed in the moderate state-anxious group. For younger children, there were 12 subjects in the low ($\bar{X}$ score=27, S.D.=2.14), 12 subjects in the moderate ($\bar{X}$ score-31.1, S.D.=.8) and 12 subjects in the high state-anxious group ($\bar{X}$ score=36.3, S.D.=3.1). For the older group, there were 9 subjects in the low ($\bar{X}$ score=27.4, S.D.=1.5), 15 subjects in the moderate ($\bar{X}$ score=30.8, S.D.-30.8) and 16 subjects in the high state-anxious group ($\bar{X}$ score=36.1, S.D.=3.1).

Materials

Stimuli for the training and test phases of the experiment consisted of sets of orthogonal, paired stimulus figures printed on 10 cm X 20 cm cards. The figures were exemplars of the 16 unique combinations of four bivalued dimensions: size, large and small; shape, circle and square; pattern, striped and dotted; and, color, red and blue. A deck of cards constituted a problem. For training trials these decks consisted of 46 cards and for test problems, 10 cards.

Index-sized cards were used for the memory aids. These aids consisted of visual exemplars of each dimensional value and the name of that value printed in block letters on the face of the card.

A modified version of the State-Trait Anxiety Inventory for Children was used to assess children's state anxiety during the time that they were solving problems. The modification involved asking children to describe how they felt, "while they were solving the problems," rather than how they felt, "presently." The State-Trait Anxiety Inventory for Children consists of 20 adjective statements representing a three-point continuum, e.g., "I felt very nice, nice, not nice."

RESULTS

The data were subjected to several analyses. These analyses were conducted separately for younger and older children. For each analysis, data were collapsed across problems. Two measures of solution performance were considered. One of these measures was the number of problems solved, i.e., the selection of the figure with the experimenter-defined answer on, at least, the last three outcome trials and the verbalization of the correct answer on the two intervening introtact probes. Another solution measure was speed of solution. This measurement was made by counting backward from the tenth trial to the one on which the last error occurred (Trial to Last Error, TTLE). Because at least three trials are needed to identify the problem's solution, only the last seven trials were considered in this analysis; thus, high scores reflect more rapid solutions.

In addition to analyses of solution performance, other analyses were conducted on children's use of logical rules. These rules are: the consistency with which hypotheses are tested following positive feedback (H con F+), the consistency with which hypotheses are tested following negative feedback (H con F-), the win-stay rule (maintaining an hypothesis if it is confirmed), the lose-shift rule (changing the hypothesis if it is disconfirmed), and the local consistency rule (if the lose-shift rule is used, selecting an hypothesis from the figure opposite the one chosen).

Problems were also analyzed for hypothesis testing patterns. Two hypothesis testing patterns were scored; these were: focusing and random hypothesis sequences (i.e., hypotheses use without regard to feedback). In order to be credited with the use of a focusing strategy, children had to use all of the aforementioned rules appropriately, receive negative feedback on either the second or third outcome trial, and successively eliminate hypotheses from the set of values defining the first positive exemplar of each problem set.

Solution Performance

Number of Problems Solved. The mean number of problems solved and trials-to-last-error are reported in Table 1. An inspection of this table will show that younger children solved more problems when provided with memory aids, $F(1.33)=11.4$, $MS=.49$, $p<.01$. There was no effect for anxiety nor was the interaction significant. No main effects, interaction or trends were found in an analysis of the older children's data.

TTLE. An inspection of Table 1 will reveal that for both younger and older children, memory assistance facilitated speed of solution, $F(1.33)= 15.76$, $MSe= 1.68$, $p<.01$, for younger children and, $F(1.34)= 5.11$, $MSe= 2.04$, $p<.05$ for older children. Neither the main effect of anxiety nor the interaction reached significance for either age group.

Logical Rule Use

Of the five logical rules mentioned above, the results of the H con F+ and the lose-shift rule are not reported due to the lack of variability and the near perfect use of these rules by both age groups. The means for the frequency with which each of the remaining rules were used as a function of the conditions created by the combinations of memory assistance and anxiety level are reported in Table 2.

H con F-. Analysis of the percentage of instances in which the H con F- rule was used by young children revealed a significant main effect for memory condition, $F(1.33 = 3.58$, $MSe = .003$, $p < .05$; young children used this rule more frequently when provided memory aids. There were no significant main effects, interaction, or trends in the analysis of the older children's data.

Win-Stay Rule. For the younger children, the data analysis showed that anxiety had a marginal effect on performance, $F(2,33) = 2.75$, $MSe = .06$, $p < .1$. As seen in Table 2, as anxiety increased, the appropriate use of the win-stay rule decreased. No main effects, interaction, or trends were found in an analysis of the older children's data.

Local Consistency Rule. An analysis of the frequency with which younger children were locally consistent revealed a trend for both memory condition, $F(1.33) = 2.73$, and the interaction between memory condition and anxiety, $F(2.33) = 2.46$, $MSe = .002$, $p < .1$. These trends reflect a lower level of local consistency in nonmemory assisted, moderately state-anxious children. No significant main effects, interaction, or trends were found in an analysis of older children's data.

Strategy Use

Focusing. For younger children, an analysis of the data on the frequency with which focusing occurred revealed a trend toward an interaction between memory condition and anxiety, $F(2.33) = 3.05$, $MSe = .06$, $p < .1$. A t-test conducted on the difference between cell means revealed that this trend was due to the less frequent use of focusing by nonmemory assisted, low state-anxious children. For older children, the provision of memory aids led to significantly more focusing, $F(1.37) = 10.7$, $MSe = .07$, $p < .01$; however, no effect for anxiety nor an interaction obtained (see Table 3).

Random Hypothesis Patterns. Although random hypothesis patterns were found on a good proportion of younger children's problems, no main effects, interaction, or trends were found in an analysis of these data. For the older children, it was found that high state-anxious children tended to use more random hypothesis sequences than moderately state-anxious children, $F(2.37) = 2.69$, $MSe = .13$, $p < .1$ (see Table 3).

EXPERIMENT 2

METHOD

Design and Procedure

The design and procedure were identical to that described for Experiment 1 except for the manner in which feedback and introtacts were delivered. Beginning with the second training problem and continuing on the third training problem and the remaining test problems, children were given delayed feedback.

The first training problem was identical to that reported in Experiment 1. On the second training problem, children received feedback contingent with their choices on the first outcome trial. However, following the second outcome trial, and thereafter, feedback was delayed while the stimulus card was turned over exposing a blank card. In the presence of this blank card feedback about the subject's previous choice was then given and the child was asked to guess the problems' solution. On the third training problem, feedback was provided as described above and the memory aid was introduced.

Following training, eight test problems were administered. Again, feedback was presented contingently on the first trial of each problem and thereafter delayed, i.e., presented only after the stimulus card had been removed from view, exposing a blank card. On half of these problems children were allowed to use the memory aid.

Subjects

As in the first experiment, subjects were second and sixth graders attending a private elementary school in Redlands, California. The average age for the younger children was 91.7 mo. (S.D.= 3.8) and for the older children it was 139.7 mo. (S.D.= 6.8). For younger children, 12 subjects were placed in the low anxious group ($\bar{X}$ score= 26.2, S.D.= 3.5), 12 in the moderately anxious group ($\bar{X}$ score= 30.9, S.D.= .9), and 5 in the high anxious group ($\bar{X}$ score= 34.8, S.D.= 1.9). For the older children, there were 6 subjects in the low anxious group ($\bar{X}$ score= 27.3, S.D.= 1.9), 12 in the moderately anxious group ($\bar{X}$ score= 30.8, S.D.= .58), and 18 in the high anxious group ($\bar{X}$ score= 36.6, S.D.= 4.7).

RESULTS

As in Experiment 1, several analyses were performed on these data. Two measures of solution performance were considered: number of problems solved and speed of solution (TTLE). The use of logical rules was also evaluated; however, only two of these rules are considered further, these are: H con F- and the local consistency rule. The other rules are not reported because children used them almost perfectly. The data were also analyzed to ascertain the frequency with which focusing and random hypothesis patterns occurred.

Solution Performance

Number of Problems Solved. For the younger children, the provision of memory aids facilitated problem solution, $F(1.26)= 14.52$, MSe= .77, $p < .01$. Similarly, an analysis of the older children's data also revealed a main effect for memory assistance, $F(1.33)= 10.5$, MSe= .61, $p < .01$ (see Table 4.)

TTLE. An analysis of older and younger children's data on the speed at which problems were solved reveals that memory assistance prompted more rapid solutions in both groups. For younger children, $F(1.26)= 27.94$, MSe=2.7, $p < .01$,

and for older children, $F(1.33) = 14.05$, $MSe = 1.77$, $p < .01$ (see Table 4). For older children, children in the high state-anxious group tended to solve problems more slowly than those in the other two anxiety groups, $F(2.33) = 2.56$, $MSe = 1.99$, $p < .1$ (see Table 4).

Logical Rule Use

H con F-. The mean frequency with which both the H con F- and the local consistency rules were used appropriately as a function of memory assistance and anxiety are reported in Table 5. For younger children, the use of the H con F- rule was unaffected by either the provision of memory aids or anxiety.

For older children, a marginal effect was found for both anxiety, $F(2.33) = 3.01$, $MSe = .02$, $p < .1$; and their interaction, $F(2.33) = 2.76$, $p < .1$. An inspection of Table 5 reveals that these trends resulted from the poorer performance of children placed into the low anxious group compared to the other two groups and it was this group that benefited most from the provision of memory aids.

Local Consistency Rule. For the younger children, there were no main effects, interaction, or trends in an analysis of the frequency with which they used the local consistency rule. Older children, while not particularly influenced by the provision of memory aids were affected by anxiety, $F(2.33) = 3.29$, $MSe = .05$, $p < .05$ (see Table 5). Children placed into the low state-anxious group were less locally consistent while solving problems than were moderately state-anxious children (although they didn't differ significantly from children placed into the high state-anxious group).

Strategy Use

Focusing. An analysis of the data on the frequency with which younger children used the focusing strategy revealed that they exhibited more focusing when provided with memory assistance, $F(1.26) = 6.49$, $MSe = .07$, $p < .05$ (see Table 6.) No effect

was found for anxiety nor was there an interaction. An analysis of the older children's data failed to reveal any main effects, interaction, or trends.

Random Hypothesis Sequences. The most common pattern of hypotheses to be observed in these problems was the random hypothesis sequence. For younger children, the provision of memory aids significantly reduced the number of random sequences, $F(1.26) = 6.32$, $MSe = .06$, $p < .05$, although anxiety did not affect the production of these sequences. There were no main effects, interaction, or trends in an analysis of the older children's data (see Table 6).